Economic Potential for Soil C Sequestration in the Central U.S.: The Opportunity Cost Approach

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Objectives

- Develop economic method to assess economic soil C sequestration potential (construct carbon supply curves)
  - Uses concept of opportunity cost to assess economic potential
  - Uses available secondary data
  - Uses estimates of c rates from IPCC methods or process models
- Apply this method to Central U.S. using ag census data

Opportunity Cost Method

Under suitable assumptions*, the condition for participation in soil C contract is:

$$g(i,j) > NR(p, w, z, i) - NR(p, w, z, j) + FC(i,j) + TC$$

$g(i,j)$ = payment for switching from practice i to j
$NR(p, w, z, i)$ = net returns to practice i
$FC(i,j)$ = annualized fixed costs
TC = transactions cost

*Antle and Diagana, AJAE, December 2003.

Opportunity Cost Method (2)

Define the *farm opportunity cost* of changing from practice *i* to practice *j* as

$$OC(p, w, z, i, j) = NR(p, w, z, i) - NR(p, w, z, j)$$

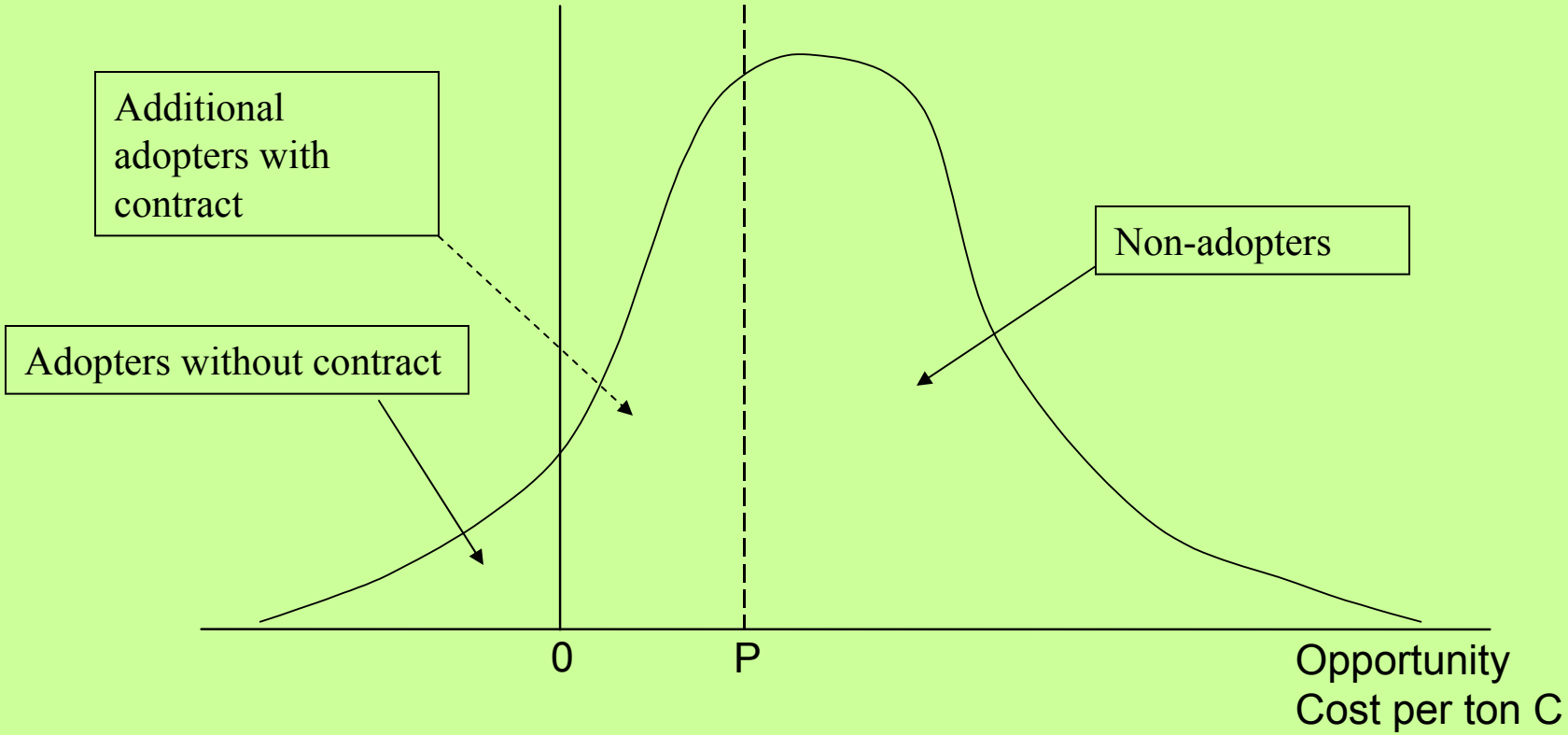
The *opportunity cost method* utilizes spatially-varying data to estimate the spatial distribution of OC, plus estimates of FC and TC, to construct carbon supply curves.

Opportunity Cost Method (3)

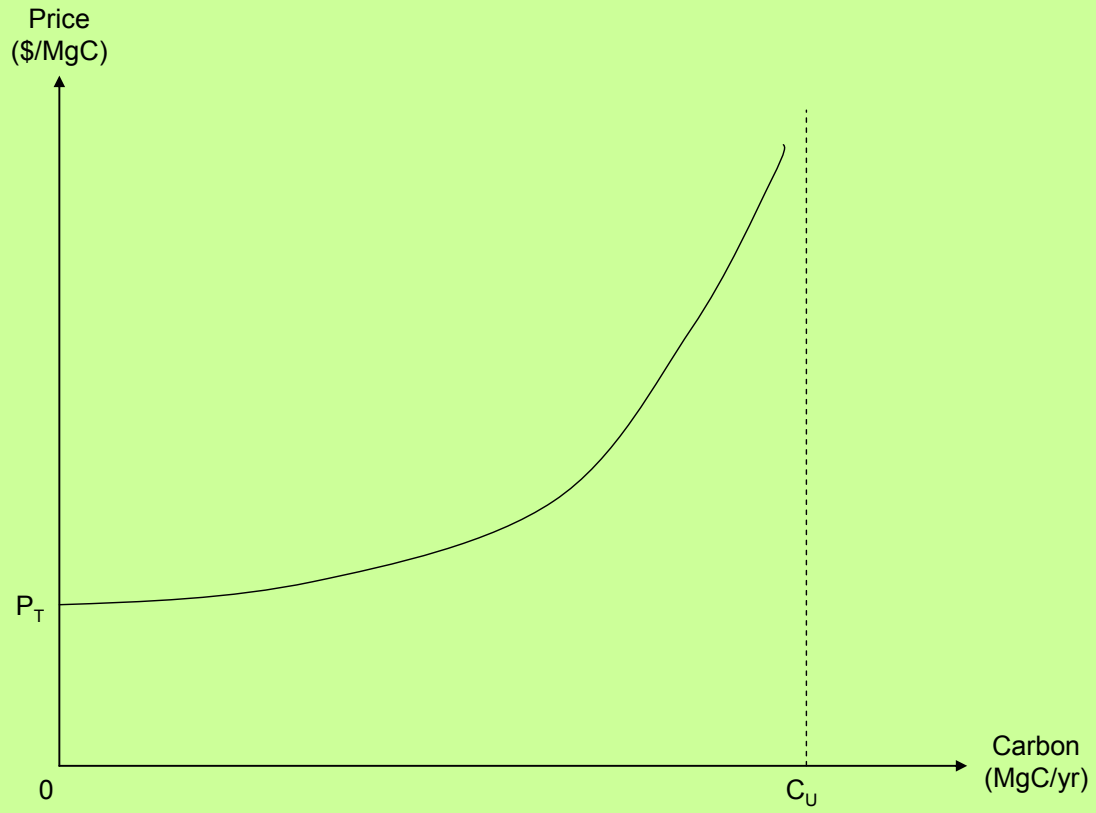
For a per-ton carbon contract, $g(i,j) = P \cdot \Delta C\ (i,j)$, where P is the price per metric ton of carbon and $\Delta C(i,j)$ is the annual average rate of carbon accumulation for (i,j), the condition for contract participation is:

$$P > \{NR(p, w, z, i) - NR(p, w, z, j) + FC(i,j) + TC\}/\Delta C(i,j)$$

Spatial Distribution of OC and Contract Participation Decisions



Summing land units participating in contracts at each price gives carbon supply curve (P_T is threshold associated with transaction cost)



Estimation of OC Model for Fallow and Conservation Till Acres Using Ag Census Data

- 1987, 1992, 1997 Ag Census, 21 States, 4608 county observations
- Conservation tillage data from CTIC
- Regional price data for crops (wheat, corn, soy, hay) and inputs (fertilizer, labor, fuel)
- USG Ecozone dummy variables
- Net Returns (profit) function estimated using NL least squares

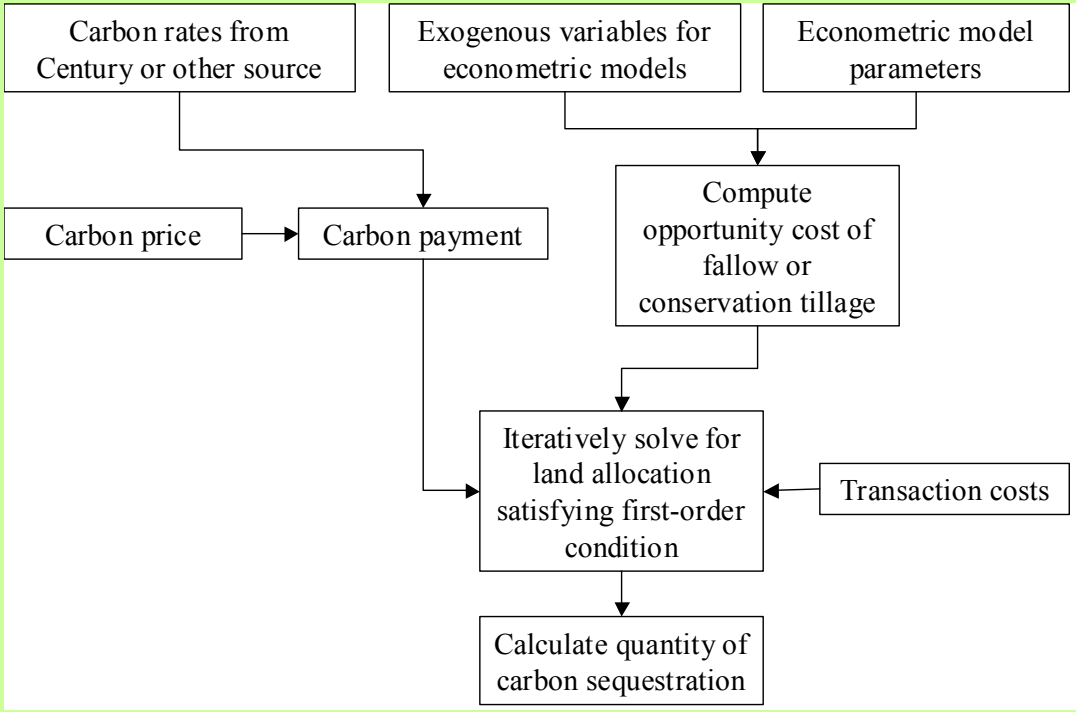
  - log-linear in prices and exog vars, quadratic in fallow acres and conservation tillage acres

  - NR is used to simulate opp cost of reducing fallow or increasing conservation tillage

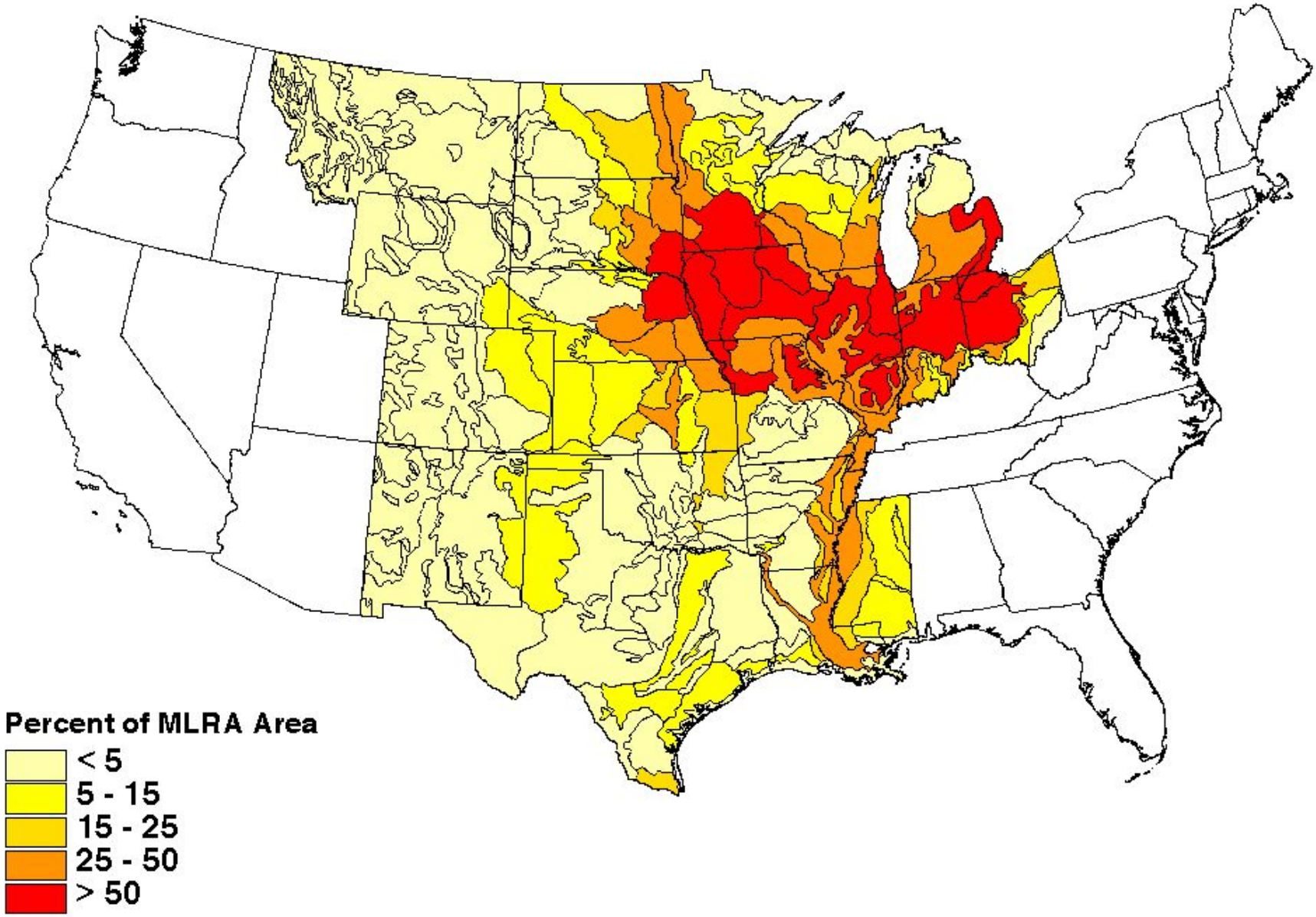
Simulation Model

- 1997 exogenous variables used to compute OC at observed acreage allocation
- Model iteratively allocates land to contracts until

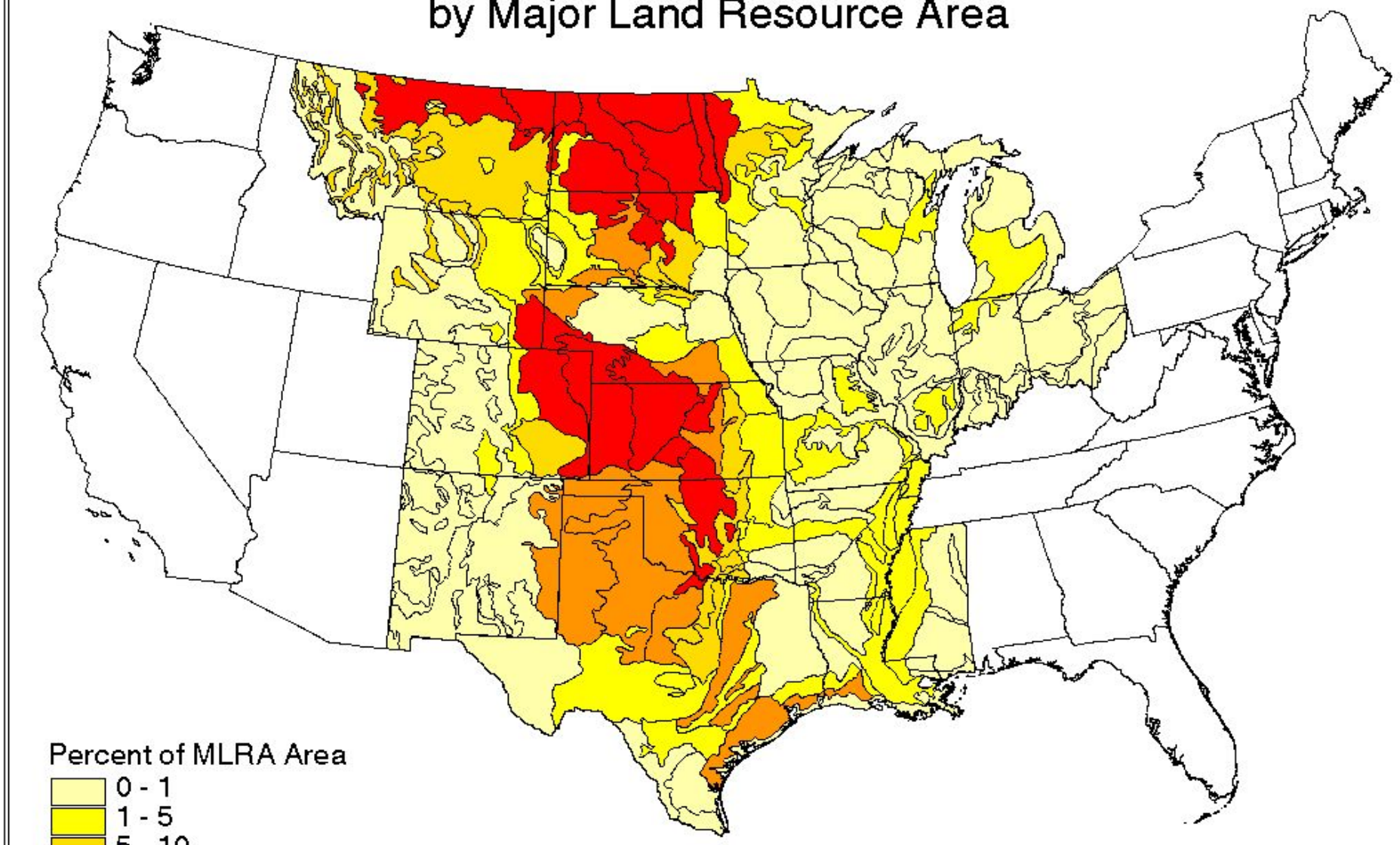
carbon payment = opp cost + trans cost



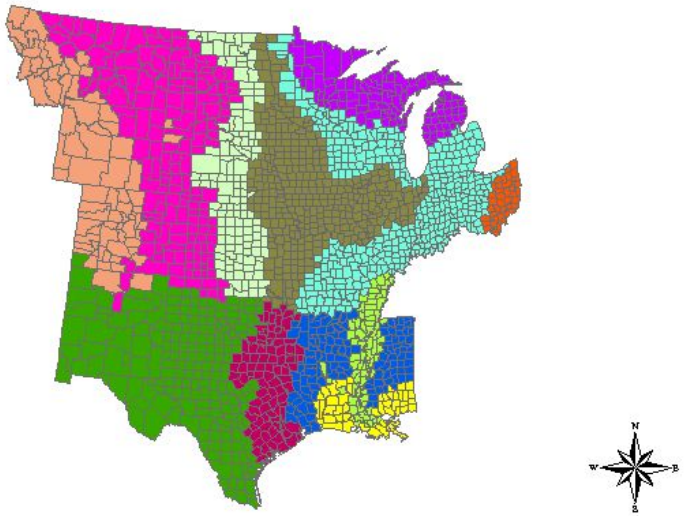
Percent Rowcrop by Major Land Resource Area



Percent Small Grain
by Major Land Resource Area



Ecosystem Grouping for the Central U.S. Data

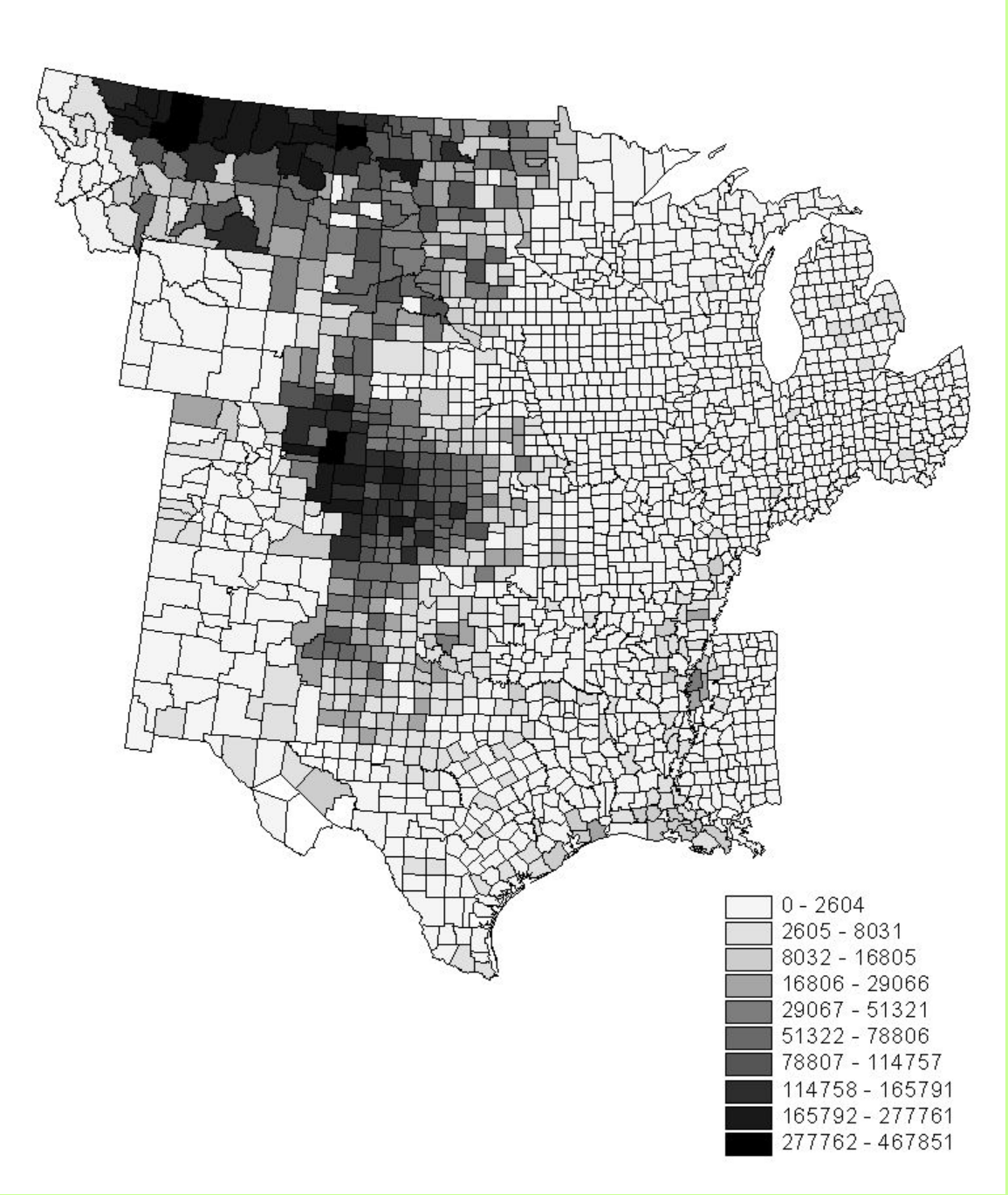


Legend

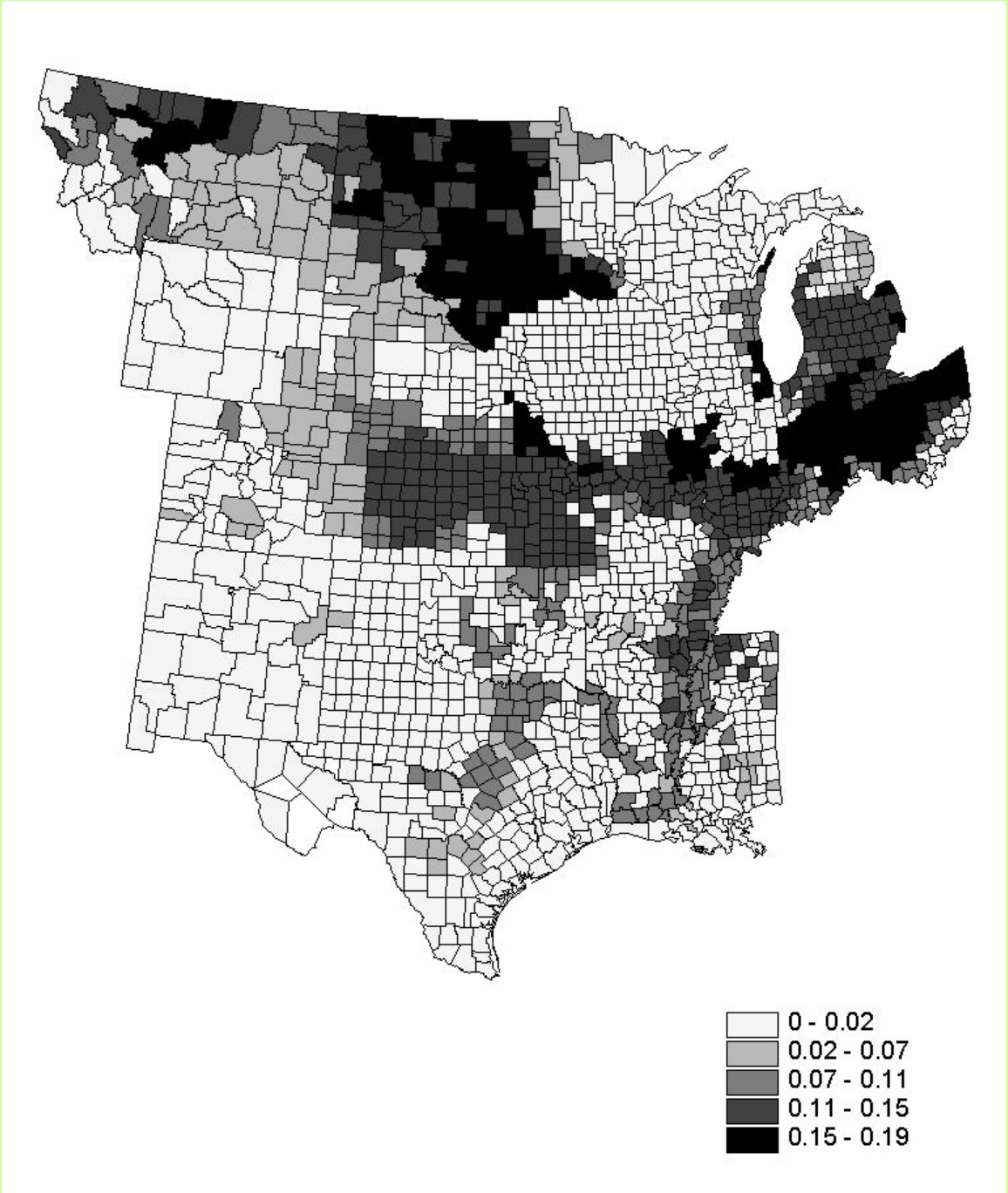
- Eastern Broadleaf Forest (Continental)
- Lauretian Mixed Forest
- Outer Coastal Plain Mixed Forest
- Lower Mississippi Riverine Forest
- Southern Mixed Forest / Ouachita Mixed Forest - Meadow
- Southwest Plateau and Plains Dry Steppe and Shrub
- Great Plains - Palouse Dry Steppe
- Rocky Mountains Steppe - Open Woodland - Coniferous Forest Alpine Meadows
- Prairie Parkland (subtropical)
- Great Plains Steppe
- Prairie Parkland (temperate)
- Eastern Broadleaf Forest (Oceanic)

Montana State University Capalbo/Antle

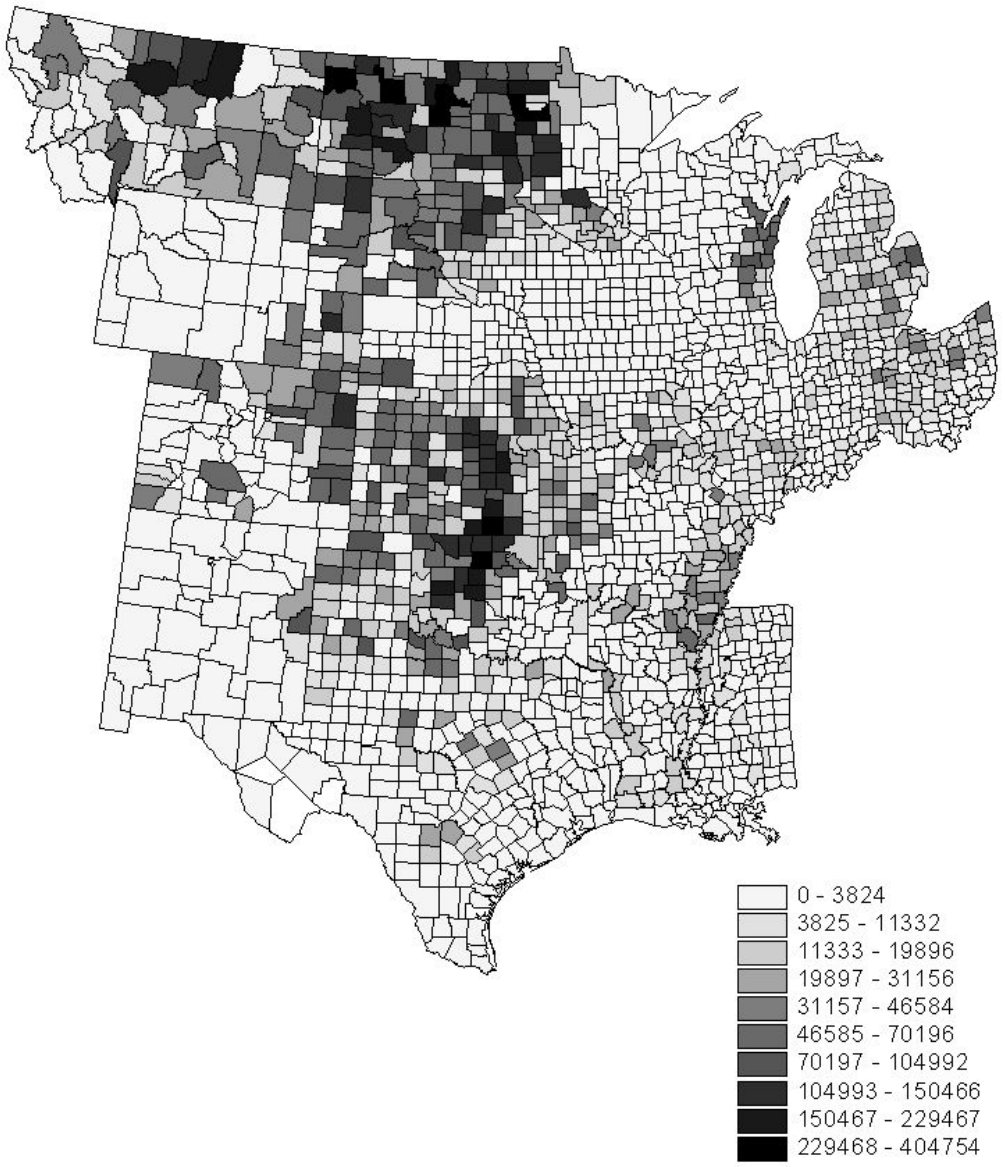
Wheat acreage in crop fallow rotation in the central United States (Source: U.S. Census of Agriculture).



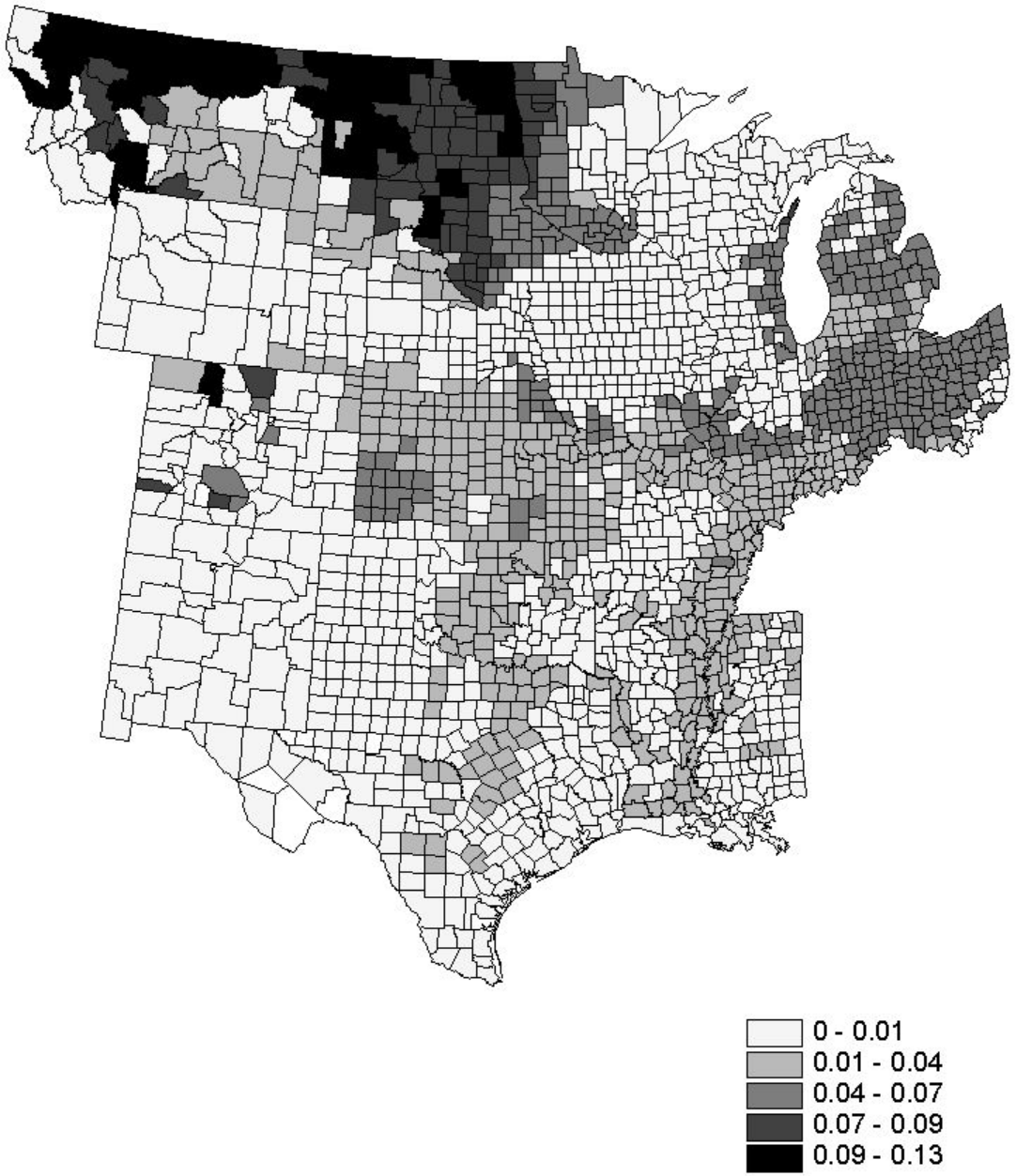
Expected 20-year soil carbon rates (MgC/acre/yr) for reduction in wheat fallow acreage in the central United States estimated with the Century model.



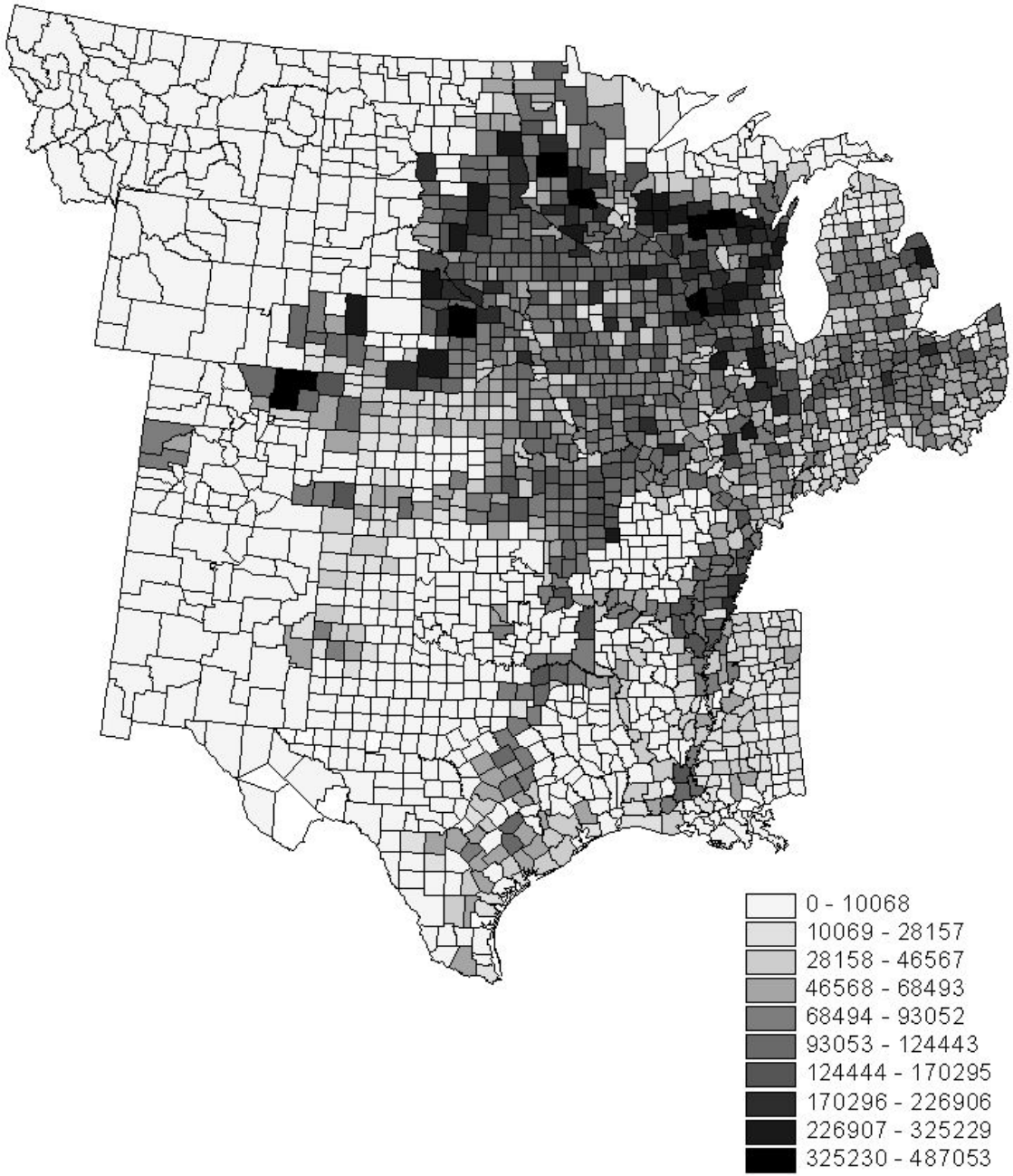
Wheat acreage produced under conventional tillage in the central United States. (Source: Conservation Tillage Information Center).



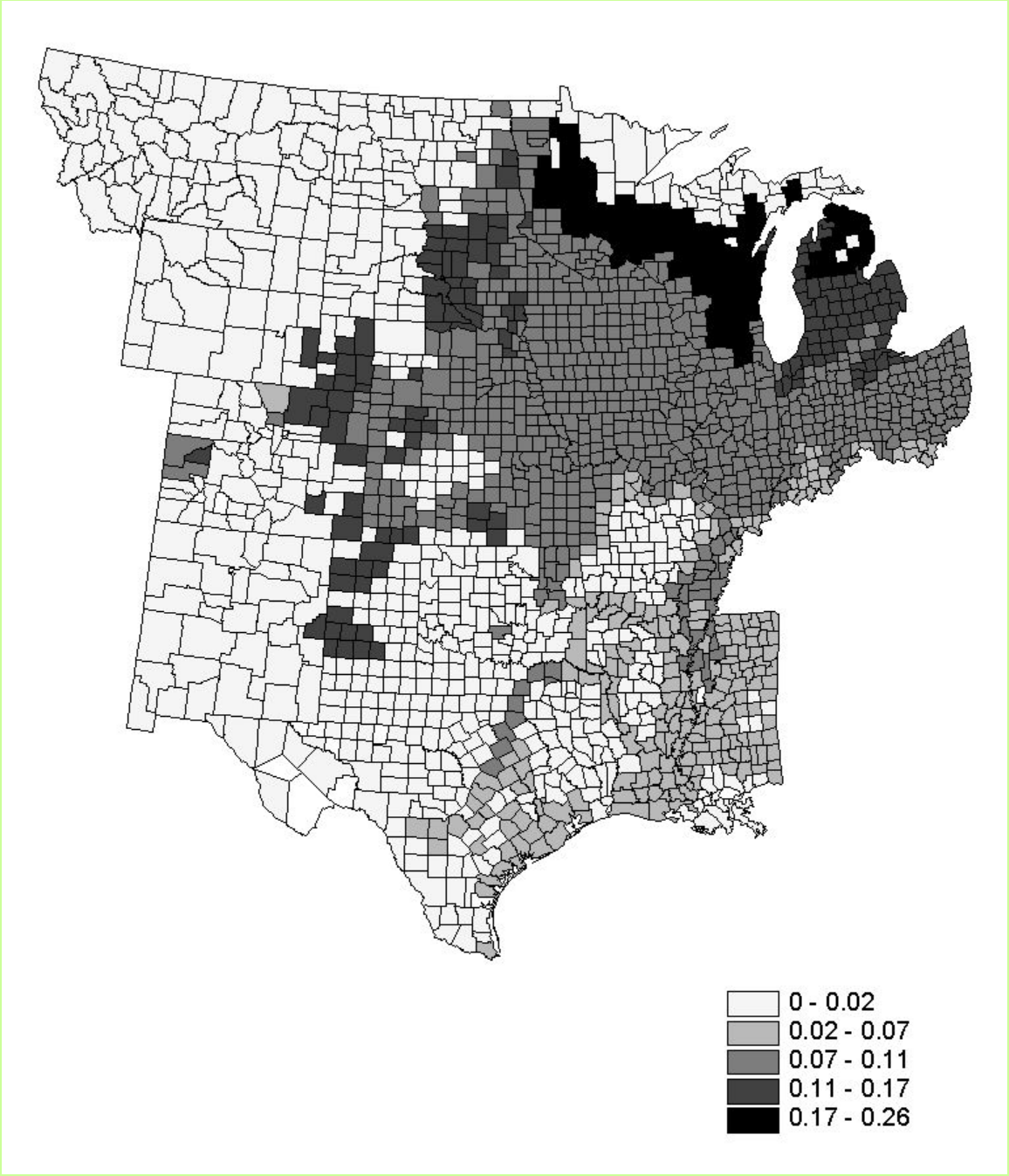
Expected 20-year soil carbon rates (MgC/acre/yr) for adoption of conservation tillage in wheat in the central United States estimated with the Century model.



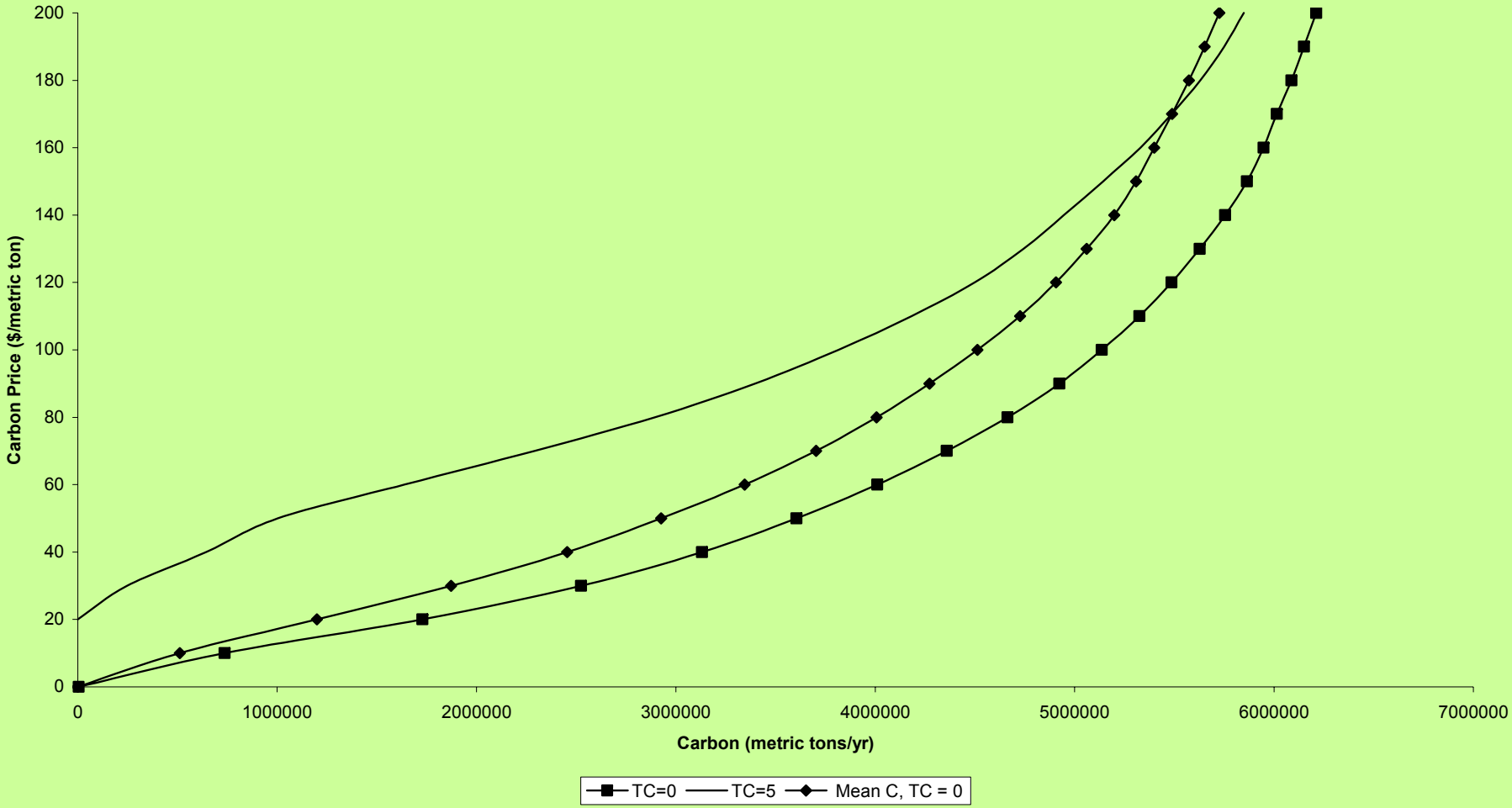
Corn, soy and feed acreage produced under conventional tillage in the central United States. (Source: Conservation Tillage Information Center).



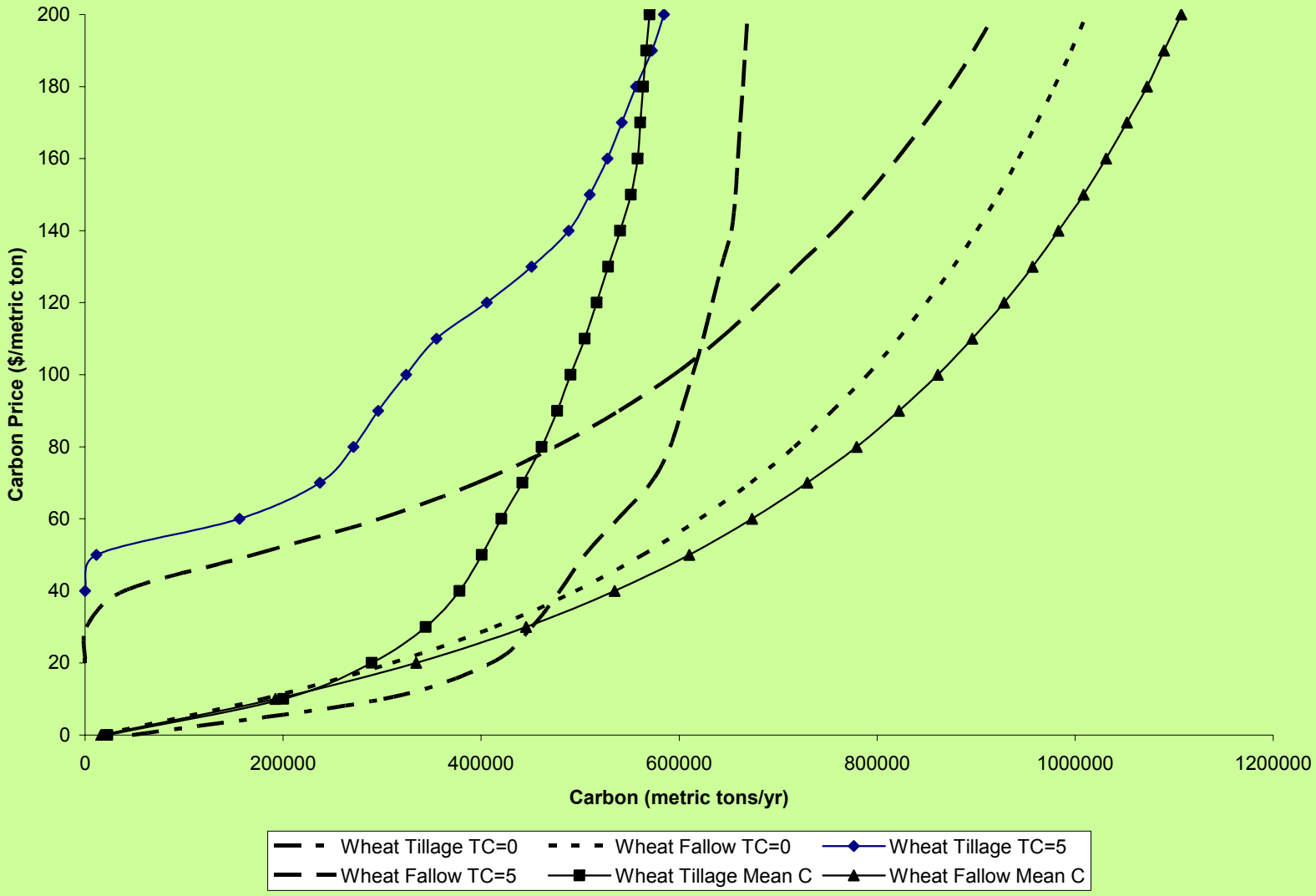
Expected 20-year soil carbon rates (MgC/acre/yr) for adoption of conservation tillage in corn-soy-feed in the central United States estimated with the Century model.



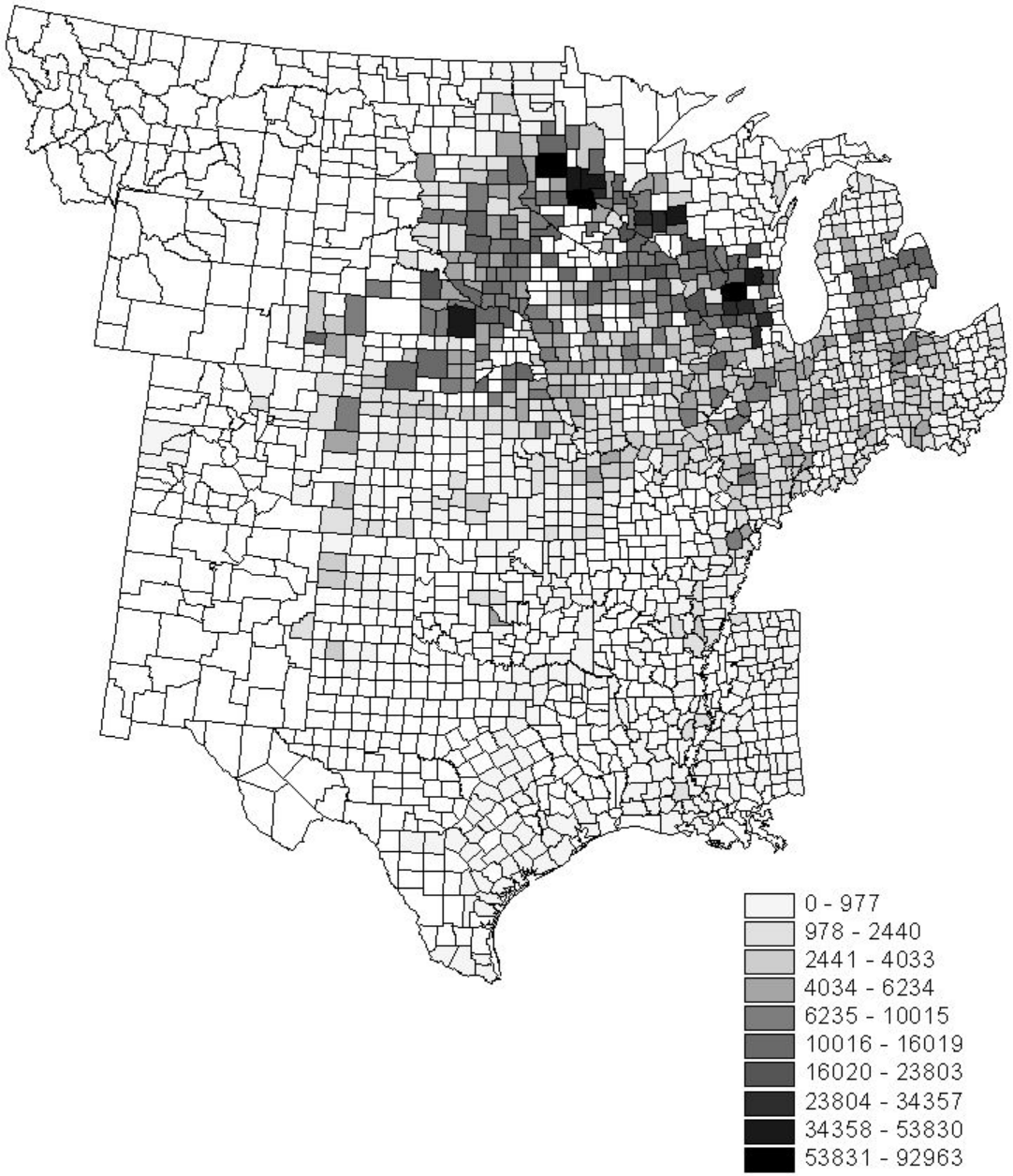
Carbon supply curves for adoption of conservation tillage in the corn-soy-feed system, central United States, for county carbon rate estimates and for mean carbon rate. TC denotes transaction cost ($/acre).



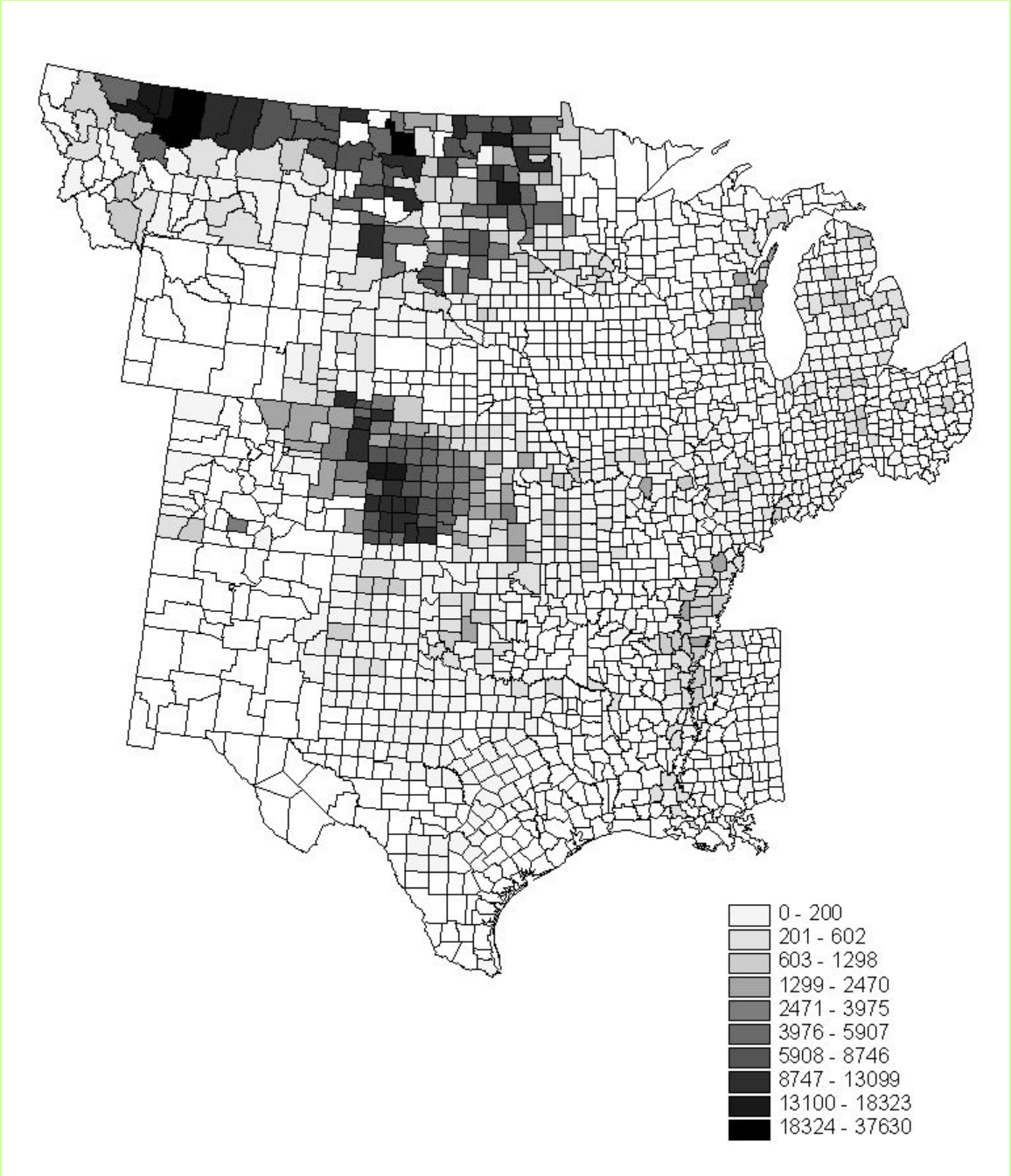
Carbon supply curves for fallow reduction and conservation tillage adoption, central United States, for county carbon rate estimates and for mean carbon rates. TC denotes transaction cost ($/acre).



Soil carbon (MgC/ac/yr) sequestered from adoption of conservation tillage in wheat and corn-soy-feed in the central United States with a carbon price of $50/MgC.



Soil carbon (MgC/ac/yr) sequestered from wheat fallow reduction in the central United States with a carbon price of $50/MgC.



Conclusions

- Simple model based on opp cost produced estimates similar to those of more complex, data-intensive models
- reduction in fallow and conservation tillage adoption in the wheat system could generate up to about 1.7 million MgC/yr at a price of $200/MgC.
- increased adoption of conservation tillage in the corn-soy-feed system could generate up to about 6.2 million MgC/yr at a price of $200/MgC.
- Due to the relatively high price elasticity of response, about half of this potential could be achieved at relatively low carbon prices (in the range of $50 per ton).

Conclusions (cont.)

- Using average carbon rates, the aggregate econometric-process model produced carbon sequestration estimates within about 10% of those based on county-specific carbon rates, suggesting that effects of spatial heterogeneity in carbon rates may average out over a large region such as the central United States.
- Average carbon rates produced large errors in predictions for individual counties, showing that estimates of carbon rates need to be matched to the spatial scale of analysis.
- Transaction costs were found to have a potentially important impact on soil carbon supply, particularly when carbon rates are low, by creating a threshold effect on the supply curves, although this effect diminishes as carbon prices increase.